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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Steam Cylinder Lubrication

A New Chart for Viscosity Temperature Relations

PUBLISHED MONTHLY BY
THE TEXAS COMPANY
PETROLEUM AND ITS PRODUCTS

The Old Tallow Pot

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Steam Cylinder Lubrication

WHILE the reciprocating engine, as a means of production of great power, may have been replaced by the steam turbine in many instances, the difficulties of the lubricating engineer in steam cylinder lubrication have not been appreciably reduced. The reciprocating units replaced by turbines were generally of the large highly developed type, running with fairly constant load, and hence the easiest to lubricate as far as the steam cylinders were concerned. Steam conditions in this type were nearly standardized, and the steam cylinder lubricant was not required to take care of conditions which might vary widely in a short time. For the production of power by means of medium sized or small units, especially in isolated plants or under conditions where the power used may vary rapidly or may be required to reverse direction suddenly, the reciprocating type of engine is still supreme. This type of unit has always been the most difficult to lubricate on account of the varying temperature, pressure, and saturation of the steam. It is far more difficult to ascertain whether a steam cylinder is efficiently and economically lubricated or not than it is to determine the same condition with bearings, because the inside surface of the cylinder cannot be seen or felt while the engine is running. Wear in a cylinder cannot usually be detected except on examination when the cylinder head is removed. Cylinders and valves cannot be examined every day, so the tendency is to use an excess of oil in order to be sure of getting enough.

In discussing this subject we shall consider:

1. What the oil must lubricate,
2. How it can best be applied,
3. The conditions under which it must operate,
4. The selection of oils to meet these operating conditions,
5. How to tell if lubrication is correct.

Surfaces to Be Lubricated

Broadly speaking, a cylinder oil is required to lubricate every sliding surface which comes in contact with the steam. In reality this includes not only such surfaces as may actually be touched by the steam but those moving parts which are heated by it or are under its pressure. The principal parts that must be lubricated are: (a) the admission or controlling valve and valve rod, (b) the cylinder walls, (c) the piston and piston rings, (d) the piston rod, and (e) the exhaust valve if different from the admission valve. In addition the oil generally must lubricate the main stop valve and throttle. These various surfaces are usually under different pressure and temperature conditions in

the same machines, and the lubricant must take care of these varying conditions equally satisfactorily. As machines vary considerably in their controlling valve mechanism we shall discuss that first.

There are in general four types of valves: (1) the slide valve, (2) the Corliss valve, (3) the piston valve, (4) the poppet valve. The slide valve, operating, as it does, with an excess pressure on one side, is exceedingly difficult to lubricate, as the tendency is to continually scrape the oil away from the valve seat, giving a maximum opportunity for wear and leakage. This, of course, could be somewhat prevented if the edges of the valve and its seat could be chamferred, but while this procedure would assist in the lubrication it would result in poor steam economy and hence is unthinkable. To produce satisfactory lubrication of the slide valve, therefore, the oil film must be continually renewed. On account of this difficulty it has been found impractical to operate slide valves at a pressure much over 125 lbs. per square inch.

In the case of the Corliss valve, while there may also be quite an unbalanced pressure it is not as serious as with the slide valve, and somewhat higher steam pressure may be carried. It is quite difficult, however, with this type of valve to maintain a satisfactory oil film at the end of the valve. It is generally necessary to provide special means of lubrication, as an auxiliary lubricator or lubricating line, to this point.

The poppet and piston valves, being balanced as to steam pressure on the sliding surface, are not subjected to this tendency of squeezing the oil from between these surfaces, and hence can carry much higher steam pressures than the slide and Corliss types of valves. In the piston valve, however, a seal must be maintained between the different parts of the valves to prevent leakage of steam and loss of power.

The valve rods are usually comparatively small with little friction, but quite serious trouble may result in the running of the engine if they are not properly lubricated. Their adjustment is very exact and any overheating may cause a change of alignment with a possible sticking of the valve and a waste of power. This is particularly true of the poppet valve stem, which must be well lubricated and free from carbon in order to get quick action.

In reversing engines especial care must be taken in the lubrication of the valve rods and valves as usually the reversing is done by hand and the action must be easy and free.

While the nominal duty of the oil within the cylinder is to lubricate the cylinder walls, the proper lubrication of the piston rings and the piston rod is equally as important. Horizontal engines on account of the weight of the piston, require greater care in the selection of a lubricant than do vertical cylinders, and it is considered the best practice in the horizontal type of engine to have the piston supported by a tail rod so that its weight is not carried by the cylinder walls directly. This allows the piston rings to function in producing a seal and not in carrying a load. Piston rings should be rounded on the edges so as to prevent the scraping off of the oil from the cylinder walls, and the rings also should be so designed as to float freely around the piston, thus taking up any misalignment due to unequal expansions or otherwise.

Application of the Oil

Having considered what the oil must lubricate, the next question is how the oil can best be applied. There are two methods in common use: (1) The direct system, and (2) the atomization system. In the former the oil must be applied to each of the separate surfaces which it is desired to lubricate. In the case of the valves it is introduced directly into the steam chest, over the valve surface and around the valve rod. With Corliss valves the oil is applied near the end, as this point is most apt to run dry. From there it works along the remaining surface of the valve. The cylinder wall receives its lubricant either by a feed to the top of the cylinder, from which it drains to the walls, or by one or more feeds to the walls direct. The oil is spread over the surface by the movement of the piston. The piston and valve rods are lubricated by oil applied directly to the gland or stuffing boxes or to the rod outside the cylinder. With a single cylinder engine this system of oiling may not be so cumbersome as to make it objectionable, but when attempts are made to lubricate all sliding surfaces of multiple engines by individual oilers

the number of points that must be watched is so multiplied that the chances of failure are greatly increased.

The second or atomization method for applying the oil aims to eliminate a large number of separate oilers by making the steam act as the carrier of the lubricant. This is possible as the steam reaches practically all of the surfaces to be lubricated. To do this satisfactorily the oil must be completely atomized before it reaches the parts requiring lubrication. This process is technically known as lubricating the steam. If any of the oil is carried into the cylinder in the liquid state this effect is lost, as it either will be carried out again by the exhaust steam or will not distribute satisfactorily over the surfaces.

Point of Introduction

The problem then is to introduce the oil into the steam line (a) at the best position, and (b) in the most efficient manner. The ideal place for the introduction of the oil is into the steam line to the cylinder six or eight feet above the throttle valve. If the point of introduction is too close to the cylinder, complete atomization may not take place, while if it is too far away there is danger that the oil will be deposited on the sides of the steam pipe and will flow to the valve chest in liquid form. This deposition will take place particularly in case there are any bends in the pipe subsequent to the place where the oil is introduced, or if the valve has surfaces or pockets which may form a settling place for the oil. If these conditions are serious it may be necessary to introduce the oil into the steam pipe close to the cylinder or even into the steam chest direct. This is very undesirable as it gives much less time for atomization and either larger quantities of oil may be necessary or a type of oil must be used which will atomize very easily and may not be the best type for the lubrication of the parts affected. If the oil must be introduced near the cylinder it may be advantageous to do so at more than one point in order to get a better distribution of lubricant over the rubbing surfaces. Ordinarily, however, one point of introduction of the oil into the steam line is sufficient, and even in the case of multiple cylinder engines under certain conditions sufficient oil may be carried through to lubricate the low pressure cylinders without the use of an additional lubricator. If, however, there are receivers and re-heaters between the cylinders of multiple type engines the flow of steam may be so checked that the oil will be thrown out and collect in the bottom of the receivers. In these cases it may be necessary to install lubricators on the steam chest of the intermediate and low pressure cylinders, but they need only supply a small amount of oil to make up for that thrown out in the receivers.

In case the cylinder is jacketed by the live steam before its admission to the steam chest it is generally considered necessary to install the lubricators on the steam chest and introduce at two points if the path of the steam divides. This type of installation requires more oil than if the cylinder were not thus jacketed. Sometimes where several units are on the same steam line it may be possible to use only one lubricator to supply the oil, if it is placed well back in the line. This, however, is not generally satisfactory, as the steam leads may branch off at such angles that the oil is driven past them and is not distributed properly to all the units.

Lubricators

There are two general types of lubricators used in steam cylinder lubrication: (1) The hydrostatic type, and (2) the mechanical type. In some cases of direct application, small sight feed cups or similar devices are also used.

The hydrostatic type of lubricator, working on the principle of forcing the oil into the lubricating line by means of a head of water produced by condensed steam, is somewhat erratic. Conditions may change the amount and temperature of the water and hence the head, and changes in temperature may vary the viscosity of the oil so that a constant and regular flow is not maintained. The amount of oil flowing into the lubricating line will be independent of the load or speed of the engine, and hence the lubricated parts will not receive the varying amounts of oil required to take care of the changing speed conditions.

In the mechanical type of lubricator, as it is generally geared directly to the engine, the oil is forced into the line at a rate which varies directly with the speed of the engine, thus giv-

ing a lubrication more commensurate with the requirements. When the engine stops, the lubricator also stops feeding, thus avoiding waste by flooding the engine with oil when it is not in operation. Most mechanical lubricators have sight feed cups so that the rate at which the oil is fed to the line can be ascertained at any time. In the multiple type of lubricator where one piece of apparatus feeds a number of lines, sight feeds with separate regulating devices should be installed in each line. The best types of lubricator will feed the same amount of oil regardless of temperature, viscosity or amount of oil in the receiver. Some types keep the feed pipes full by means of spring check valves, which also are vacuum proof. This causes oil to be fed the instant the engine is started. The mechanical lubricator can be used either with the direct system of application or with the atomization system, but the hydrostatic type is generally only used on the latter.

Atomizers

In the atomization system one of the most important details is the means by which the oil is broken up into such a fine mist that it will be easily carried by the steam throughout the system and not settle out in the pipes or in dead steam passages. This is accomplished by feeding the oil into the line at a point where the velocity of the steam is high. In some installations the oil feed line is extended to the center of the main steam pipe and flattened out in the shape of a spoon, so that as the steam strikes it the oil is blown off in a fine spray and mixes completely with the steam. Another method is to extend the oil feed pipe across the steam line and perforate it with small holes. Great efficiency is claimed for the use of fine slots lengthwise on the oil feed pipe, instead of these holes. Other things being equal, saturated steam is more efficient in atomization than superheated steam. Which type of atomizer to recommend is difficult, as the conditions of temperature, saturation and velocity of steam, and viscosity and kind of oil, as well as position of atomizer, will all govern the atomization. What may be completely satisfactory in one case may be inefficient in another, and in fact at very low steam velocities atomization may fail entirely.

Operating Conditions

Now let us consider what conditions a cylinder oil has to meet and how they can be met satisfactorily. The principal conditions affecting a cylinder oil are the pressure, temperature, percentage of moisture and the degree of superheat of the steam. There must also be considered priming and foaming of the boiler and the use to which the condensed steam is to be put after it has passed through the engine.

The steam pressure as a pressure has practically no effect on the oil but the temperature necessary to obtain the pressure and the degree of superheat have a very marked effect. The evaporation of the oil film from the cylinder, and especially the valve surfaces, will be more pronounced with high temperatures of steam than with low temperatures of steam, thus requiring either a heavier bodied oil or a larger quantity of a lighter bodied oil to obtain satisfactory lubrication. The atomization of the oil is a function of the temperature as well as of the velocity of the steam. With high temperatures a heavy bodied oil, due to the thinning effect of the heat, can be more easily atomized than it can at a low temperature. This is a decided advantage, as heavier bodied oils adhere to the cylinder walls better than do lighter bodied oils, and hence are more economical. There is a limit, however, to the length of time that it is advisable to have the oil remain on the cylinder walls, as under the temperature conditions of high superheat the oil may carbonize and cause gumming and sticking of the moving parts. This is especially true in the valve chambers, where the temperature is constantly higher than that in the cylinder. The low temperatures usually accompanying low pressures will not satisfactorily atomize heavy oils, except under very high velocities, and so under these conditions it is necessary to use an oil of low viscosity. This, however, is not as great a drawback as it may seem at first glance, as under these low temperature conditions properly refined oils do not evaporate from the lubricated surfaces too rapidly for good practice.

One of the most important factors determining the characteristic requisite for a cylinder oil

(Continued on page 9)

A New Chart for Viscosity Temperature Relations

IN THE practical use of oils it is frequently desirable to know their viscosities at temperatures other than those at which they were standardized by the refiners. It is clear that the practical user of oil is primarily interested in the viscosity of an oil at the temperature in use and at no other except as it may be a rough indication of the former. (It is a well known fact that the viscosity of all liquids decreases as their temperatures are increased.) It is equally clear that for manufacturing reasons, refiners cannot standardize and guarantee the viscosities of their stocks at all the different temperatures experienced in all classes of machinery. In order to supply the engineer with means for determining the viscosity of an oil at any temperature that is desired, curves have been used like those of Fig. I which are plotted to the usual rectangular coordinates. The use of such curves, however, reveals two prominent drawbacks: In order to include readings at moderately low temperatures, scale divisions must be used which make readings at high temperatures too small to be read, and the erroneous impression is given that all oils have the same viscosity at high temperatures. A chart of these curves is thus useful over only a moderately small range of temperatures and viscosities. The second objection is that they have so great a curvature that if they are to be plotted with any degree of accuracy a large number of laboratory readings must be made to supply the necessary data.

A close study of the various values of viscosity at different temperatures reveals the fact that temperature-viscosity relations can be so expressed by a simple formula that when plotted to the proper coordinates a straight line relationship is shown. A chart of this character has been developed by Neil MacCoull on the basis of absolute viscosities, and will be shown and discussed technically in a later issue of LUBRICATION. As, in practice in this country, viscosity readings are for convenience taken on the Saybolt Universal viscosimeter, Mr. MacCoull has prepared the modification of this chart shown in this article, in which the readings are given directly in Saybolt viscosities. At the lower viscosities this chart is not quite as accurate as the one based on absolute viscosity but the values shown, down to 40″ Saybolt, are well within the limits necessary for practical application. On this chart, if the viscosities of an oil are known at only two temperatures, a straight line drawn between these two points will show the viscosity at all other temperatures down to the "cloud test." The actual readings are shown from which the lines were plotted, which indicate the accuracy of this straight line relationship. It is recommended that the two points chosen for plotting an oil be taken at 100° F. and 210° F. since these temperatures are the two most frequently taken in laboratories now that the viscosities of all oils supplied to the U. S. Government are standardized at one of these temperatures. (See Bulletin No. 5 of Bureau of Mines.) Notice that an error of 1″ Saybolt at 210° F. makes quite a difference in the slope of the line. For this reason these readings should be taken with particular accuracy and it is recommended that a check be taken always at 210° if the reading is taken for the purpose of plotting on these coordinates.

Oils A, B, C, D, E and F, which are all straight run distillates from the same type of crude and differ but little in gravity, have lines which are almost parallel. Oils of similar viscosities but having noticeably different gravities (being from a different class of crude) have lines of a different slope, like oils N, P and U.

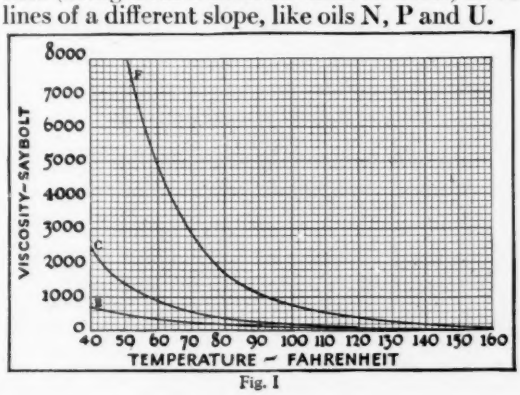
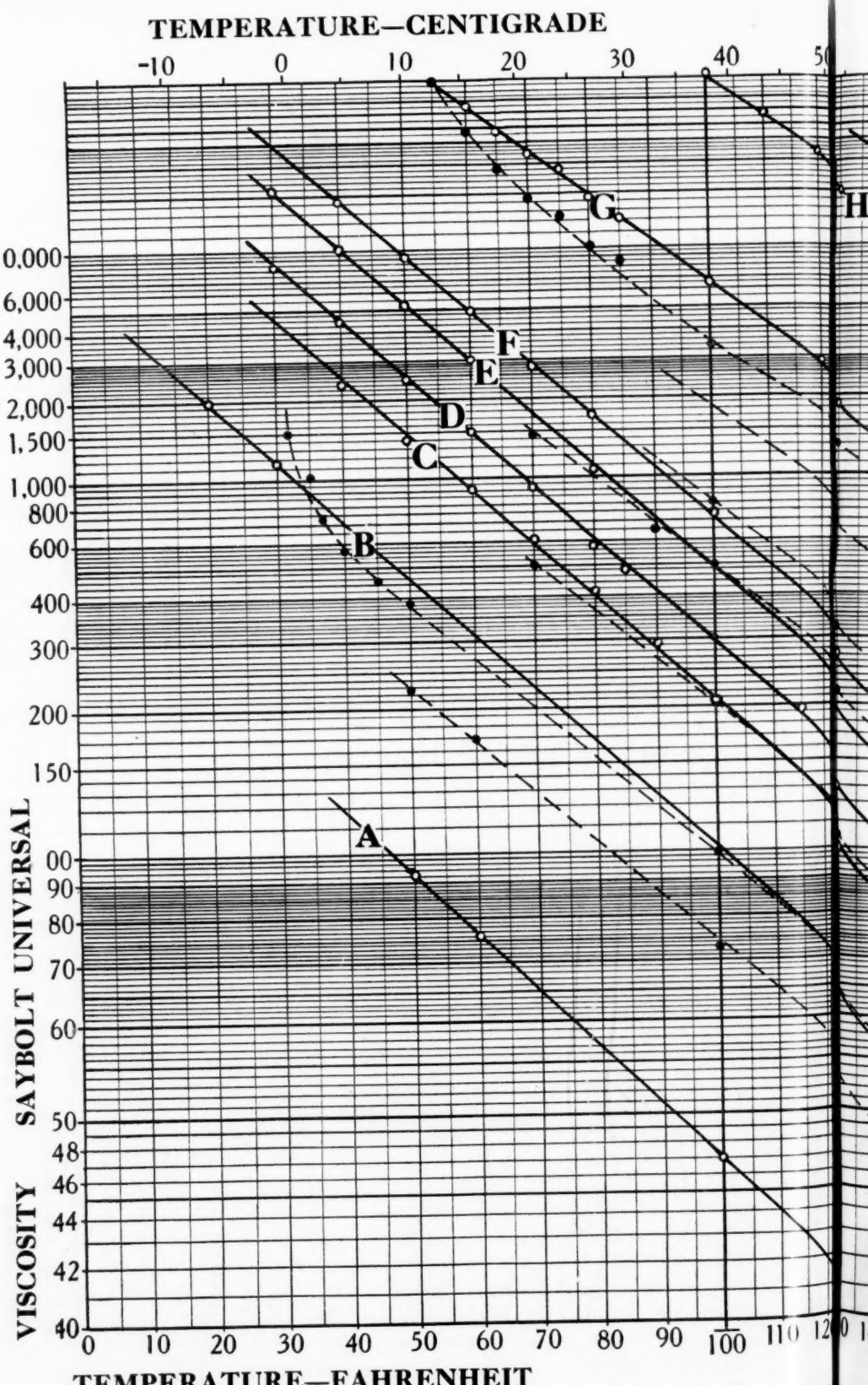
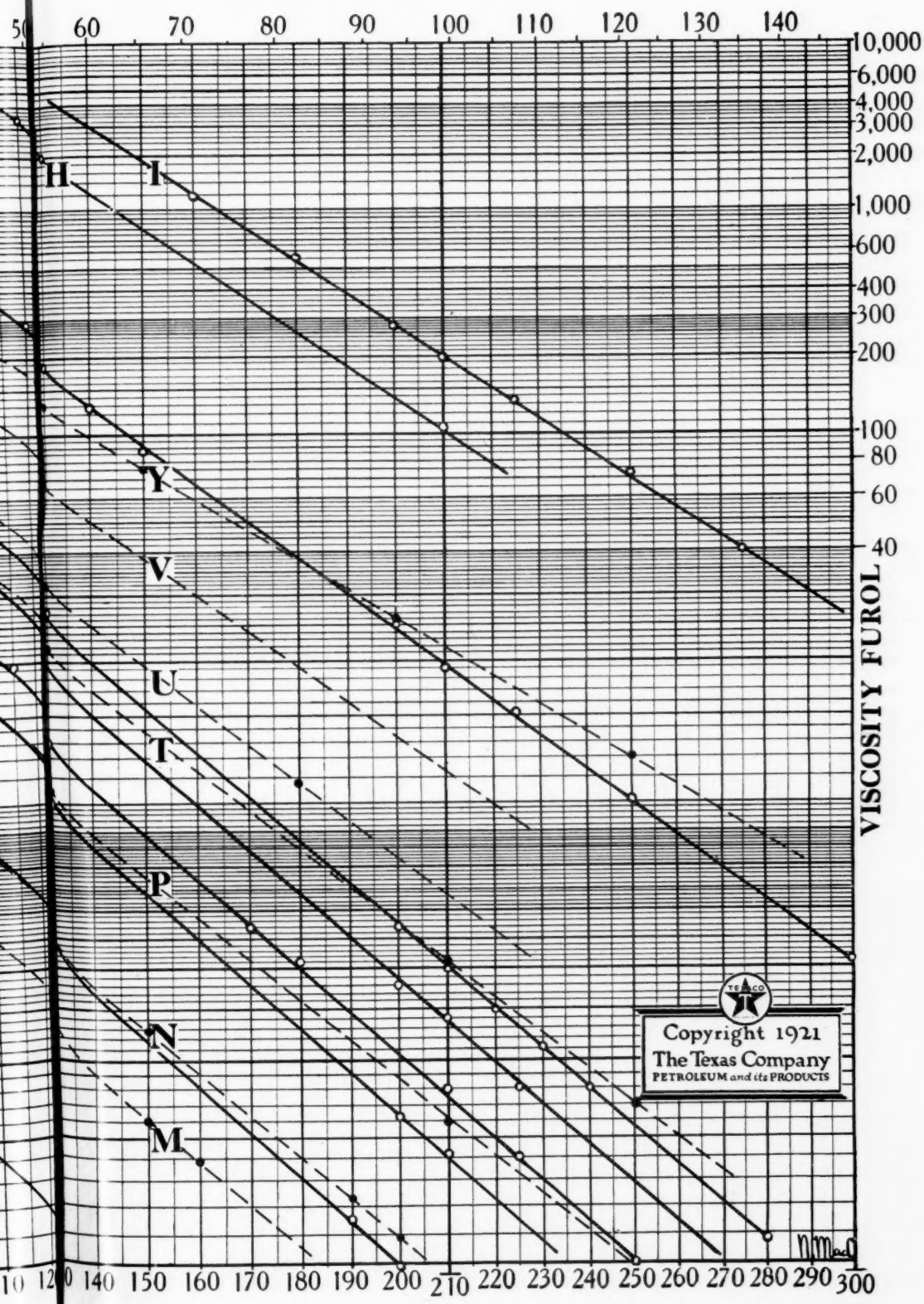


Fig. I



[VISCOSITY—TE



—TEMPERATURE CHART]

It has been found that there is no curvature to the line for any mineral oil so far tested, until the temperature has been reduced to the point where paraffine begins to precipitate, the temperature being that reported as the "cloud test" by the laboratory. Below this temperature, viscosity rises so rapidly, due to greater precipitation of the paraffine, that the line becomes concave upward like the curves for oils N and Y until it is vertical at a temperature reported by the laboratory as the "pour test." There is, of course, practically no paraffine in a well refined Naphthene base oil, such as oils A to I, and accordingly no deviation from a straight line.

It has been observed that the temperatures reported by the laboratory as the "pour test" for oils containing no paraffine, correspond to points where the lines if extended would indicate a viscosity of about 50,000″ Furol*. Thus, generally speaking, the lower the viscosity (at 100° F.) of one of these oils, the lower will be its pour test also. In routine laboratory testing, temperatures are rarely used lower than 0° F. for such tests, and a report of 0° means simply that it is zero or lower. In reality the true pour test may often be much lower, some of the oils remaining fluid down to 50° F. below zero, or even lower.

One of the most convenient features of this chart is that every known lubricating oil can be shown comparatively. It is quite interesting to know that oil I has the same viscosity at 250° as oil B at 40°. It will be noticed also that the viscosity of oil F is practically the same at all temperatures as that of oil C at temperatures 40° lower. From this it is concluded that if oil F gives satisfactory service in a machine in which the lubricating system is exposed to certain room or climatic temperatures which influence the oil temperature, then oil C should give equal satisfaction when the room or climatic conditions average 40° lower. This is a means by which the viscosity difference between Summer and Winter oils could be determined for railway journals, when the difference between average Summer and Winter temperatures is known.

Another use for a viscosity-temperature chart is afforded when it is desired to match an oil an analysis of which contains viscosity readings on a foreign viscosimeter at temperatures which do not correspond to those standard for the Saybolt. An analysis, for example, might give the Engler viscosities at 20°, 50° and 100° Centigrade, and it would be desired to find the Saybolt reading at 100° F. (37.8° C.). By means of the Viscosity Conversion Chart published in LUBRICATION for May, 1921, it would be a simple matter to determine the equivalent Saybolt viscosities at 20°, 50° and 100° C. A line drawn through these points on the viscosity-temperature chart would show at once the Saybolt viscosity at 100° F. At the same time the accuracy of the reported viscosity readings will be checked by their nearness to the straight line. If it is not possible to draw a straight line through the points given it is reasonably certain that at least one of the points given is in error.

Foreign specifications for oil usually call for the viscosity at 40° C. (104° F.), 50° C. (122° F.) or 100° C. (212° F.). In order to get the equivalent Saybolt readings at 100° or 210° F. (preferably the reading nearest the temperature given) a very fair approximation can be made by first converting to the equivalent Saybolt reading at the same temperature, and then by plotting a line through the given point, parallel to the line of some other oil of about the same gravity and viscosity.

There are some uses for oils where it is desirable that there shall be a large change in viscosity with a given temperature change, such as for example reduction gear turbines where it is possible to lubricate all parts with only one grade of oil, the required viscosities for the gears and different bearings being obtained by control of the oil temperatures at these parts. There are other uses where the least possible viscosity change should result from a given temperature change, such as in the recoil chambers of ordnance which may be exposed to any kind of climatic condition. All such information can be obtained at a glance from the lines of available oils plotted as shown in the chart.

*Saybolt Furol viscosimeter readings, shown to the right of the chart, are approximately one-tenth as great as Saybolt Universal readings for the same oil. All readings of high viscosities were taken on this instrument, or on the Redwood Admiralty instrument and conversion made by means of the Viscosimeter Conversion Chart referred to above.

STEAM CYLINDER LUBRICATION

(Continued from page 4)

is the saturation of the steam. Unless highly superheated, steam contains moisture by the time it reaches the cylinder, and even if it is not wet when it enters the cylinder some water will be produced by the cooling effect of the cylinder walls and by the heat expended in the expansion stroke. Moisture in steam will wash a pure mineral oil from the cylinder walls quite rapidly, and in order to get satisfactory lubrication under wet steam conditions large quantities of this type of oil will be necessary. This will mean that more oil will be fed into the system than can be satisfactorily atomized and carried through it, and will result in a collection of oil in the cylinder, which is an ideal condition for the production of carbon. This is especially true if the engine is of multiple expansion type and there are receivers and re-heaters between the cylinders, especially the latter. If oil is separated in re-heaters it is generally subjected to unusually high temperature conditions and even the best oil may carbonize and cause trouble on account of the carbon being carried over into the low pressure cylinders. This carbonizing effect on oil by high temperatures is especially apt to happen in the case of poppet valve spindles, and on account of their small clearances they may become so gummed that the steam action of the engine may be impeded and a loss of power brought about.

Compounding

It has been found, however, that if mineral oils are combined with small amounts of some fatty oils, as tallow or degras, a cylinder oil is produced which resists the washing action of wet steam. This compounded oil forms an emulsion with the moisture on the wet surfaces and clings so tenaciously to them that it is not washed away rapidly by the excess of water in wet steam. A large quantity of water may so dilute this emulsion that it will wash away, but an oil film will be quickly re-formed on the walls as soon as steam conditions become normal again. If, however, instead of a compounded oil a pure mineral oil is used, the moisture remaining on the cylinder walls after a dash of wet steam has passed through, is not easily displaced by the oil, and lubrication is either destroyed or at least becomes unsatisfactory. The amount of compounding required in the cylinder oil is largely dependent upon the percentage of water or moisture in the steam. An excessive amount of fatty oil beyond that necessary to form an emulsion does not improve the lubricating value of the oil and may even be a detriment, as fatty oils generally decompose under high heat conditions and may give trouble on that account. It is also difficult to maintain large amounts of fatty oils successfully in solution with mineral oils without separation or segregation. Improved refining methods have reduced the amount of compounding necessary to secure good lubrication, and now cylinder oils contain much less fatty oils than in former years.

Superheated Conditions

In engines with high superheat it has been the general practice to use heavy bodied pure mineral oils, and as a result good lubrication has not always been obtained, and it has been the general opinion that such machines are very hard to lubricate. This use of a pure mineral oil is no doubt due to the fact that cylinder oils were too often used which were not properly refined or compounded with such fatty oils as would withstand the carbonizing effect at the high temperature of superheated steam. Unless very high superheat is used, steam at the exhaust will show some moisture, and as we must lubricate the cylinder on the exhaust stroke as well as on the expansion stroke, we must use a slightly compounded oil that will take care of slightly wet conditions. Even if the exhaust from the high pressure cylinder remains dry, that of the low pressure will be wet. This, of course, can be taken care of by using a different oil on the high and low pressure cylinders, but this is not necessary as oils are now made which will take care of both conditions satisfactorily.

Priming

Another difficult condition which a cylinder oil must meet is the priming of the boiler and the carrying over of the boiler compound into the cylinder. Whether this may become serious

or not depends on the character of the boiler water and the means used to soften it. Some plants soften the water before it is pumped into the boiler, in which case if the action is completed the only effect of priming on the cylinder is the production of wet steam. But such cases are not frequent as, unless there is some compound in the water, boilers do not usually prime except under very heavy loads. Most boiler compounds contain soda, which when carried over by the wet steam combines with the fatty oil constituents in the cylinder oil, destroying at least part of its emulsifying effect. In order, therefore, to maintain a lubricating film, more oil must be fed than would normally be required. There are generally other substances besides soda carried over, however, and these combine with the oil to form sludges. These sludges choke the piston rings and valves, causing leakage of steam, loss of power, and wearing of the sliding parts. Sludges are more noticeable with heavy cylinder oils than with light ones.

The bad effects of a priming boiler may be at least partly eliminated by the use of separators before the steam enters the cylinders. These differ in design but aim to throw out the water and hence most of the impurities, allowing only fairly dry clean steam to enter the cylinder.

If wet steam from a priming boiler is passed through superheating coils the water is driven off and fine deposits of boiler impurities are formed in the coils. These deposits, consisting of iron salts and rust as well as boiler salts, are blown over by the steam into the cylinder, and not only form heavy sludges with the cylinder oil but being more or less insoluble act as abrasives, grinding the cylinders and valves. The sludges formed under these conditions by the action of the superheated steam, bake onto the exposed surfaces, and absorb more oil, thus producing ideal conditions for the carbonization of the oil absorbed. If the oil is compounded the deposits formed under these conditions, while not decreased in quantity, do not become as hard and caked as in the case where straight mineral oil is used.

Selection of Oils

We have outlined above some of the operating conditions which must be met by a satisfactory cylinder oil. It has been firmly established after many years of practical experience that in order for a steam engine to run smoothly and economically it must be lubricated with that cylinder oil which is exactly suited for its own operating conditions.

The oil must also be applied in the proper manner, at the right place, and in the right quantity. The type of engine has little bearing on the type of lubricant to use. Much more important are the temperature and pressure of the steam, its saturation, the probable degree of atomization of the oil, and the use of the exhaust steam. We shall first consider the types of cylinder oils generally manufactured, which may be used to meet the various operating conditions of the engine.

There are in general three classes of cylinder oil stocks from which the final product may be compounded:

1. Fire stocks
2. Steam refined stocks
3. Filtered stocks.

These naturally may be also subdivided according to the amount of treatment each has received. The fire stocks are the less refined and may vary considerably in quality and characteristics. They are usually more heavy bodied and sticky than the others, but will probably carbonize more quickly than more refined oils. The steam refined oils are, as the name indicates, more or less treated by live steam, the amount of treatment depending on the grade. By this treatment there are removed many of those harmful ingredients of the crude stock, which would be most likely to decompose and form harmful deposits. The filtered oils receive additional treatment to that given to the steam refined oils, by being passed through some filtering medium whereby they are brightened in color and lose most of the objectional ingredients. But these so-called objectionable ingredients, although the source of carbonization, are of the same character as those which give that desirable adhesive quality which causes the oils to cling tenaciously to the cylinder walls. The more refined oils atomize and separate from water more readily than the fire stocks or less refined oils. It is therefore evident that refining alone does not

necessarily make a cylinder oil the most suitable for the purpose, but all the operating conditions must be taken into consideration in selecting the proper oil to use.

The above stocks may be used as such, as is generally the case with marine engines, but usually they are compounded with different quantities of some suitable fatty oil. As stated previously the compounded oils are the most satisfactory to use where wet steam conditions prevail, as they are less easily washed off from the cylinder walls and valve surfaces. Different conditions may be satisfactorily met by using a combination of varying amounts of fatty oils with cylinder oils, and in many cases it is found advisable, in order to meet particular conditions, to use several fatty oils in the final products. From this it is evident that there is possible an almost endless number of compounded cylinder oils, each designed to meet a particular condition. This multiplicity naturally is impractical from a manufacturing standpoint, and the skill of the refiner is shown by his ability to so refine and compound his stocks that he can satisfactorily meet the many operating conditions with the fewest number of cylinder oils.

Viscosity

One of the most important characteristics of a cylinder oil is the viscosity. Oils of low viscosity atomize more readily than those of high viscosity. On the other hand, they also evaporate more rapidly from the cylinder walls. Conversely, although high viscosity oils require higher steam temperatures for atomization, they remain on the cylinder walls for a longer time. Other things being equal, it is generally advisable to use the heaviest bodied oils that will atomize completely under the operating conditions. Incomplete atomization, however, is a greater drawback than too light an oil. This is especially true in the case of superheated steam. While the above statement as to heavy bodied oils is generally true there are many cases, particularly with low temperature steam, where it is practical to use a lower viscosity oil and still prevent metal to metal contact. This, of course, is desirable as it reduces friction losses. This use of a lighter oil is particularly adapted to vertical engines where friction pressures are small and the principal function of the oil is to form a seal. In fact, some vertical engines run with only water lubrication. In high speed engines also friction losses due to the use of an oil of too high viscosity may more than offset the gain in evaporation made by the use of such oils, and hence a lighter oil is to be preferred.

Where steam is dirty it may be advisable to use a low viscosity oil, as in this case impurities do not stick as tightly to the exposed surfaces and hence are more easily washed away. Usually when steam is dirty it is also wet, and the temperature is not high, so that a low viscosity oil will have sufficient body under working conditions to prevent metallic contact.

Amount of Compounding

In regard to the proper amount of compound to use in an oil, it can be said axiomatically that no more should be used than is necessary in order to maintain a film of oil on the cylinder walls. The present-day tendency is more and more to reduce the quantity of compound but to improve its quality. Primarily, compounded oils are used to take care of wet steam conditions. As, except on rare occasions, there is always wet steam at some part of the system, compounded oils should always be used unless there are conditions where such use will cause more trouble than will be compensated for by the gain or economy produced. Such a condition exists where the condensed steam is reused in the boiler, or where it is used for ice making or for heating. That tendency in compounded oils which causes them to unite with water to form emulsions in the cylinders, also prevents them separating readily from water in condensed steam; also the more completely atomized the oil is the more difficult it is to separate from water. Oil in the form of fine emulsions in a boiler combines with the boiler compounds to cause foaming, or with the boiler impurities to produce a coating over the tubes and fire surfaces. This coating seems to form more readily over clean tubes than over dirty ones. A very thin layer of oily sludge over a fire surface will so insulate it that there is not only a large loss in heat efficiency but the rise in temperature of the metal may be so excessive as to cause the burning out or explo-

sion of the boiler. Even if the exhaust steam is used only for heating, the heaters become coated with the oil and lose in efficiency. This is also true if exhaust steam is used in feed water heaters. If the engines are of the condensing type, unless removed the oil will form layers on the condenser tubes with a consequent loss in power. It is necessary, therefore, in all cases where the condensed steam is used over again, to separate the oil from it.

Separators

There are many types of oil separators designed to be used either before the steam goes to the condenser or before it is fit to be pumped back into the boiler, either in whole or in part. These generally depend upon the principle of slowing the velocity of the steam so that the oil may settle down, or by causing steam to impinge upon a series of surfaces which collect the oil and drain it away from the steam. One type of separator collects the oil by spraying a small quantity of hot water into the steam before it goes to the condenser. This coalesces the oil particles so they can be segregated. In addition to these, it is generally necessary to have some filtering system before the oil is carried back into the boiler. With high vacuum the velocity of the steam may be so great as to render separation of the oil difficult.

Another factor which may determine the best viscosity of the cylinder oil to use is the type of packing. A soft packing, on account of the pressure usually employed to make it tight, requires a fairly viscous oil to lubricate it without loss of power. A metallic packing, on the other hand, can be so designed that there is very little pressure against the sliding surface, and therefore only sufficient viscosity is needed in the cylinder oil to form a seal.

Determination of Proper Lubrication

We have given above some of the factors which determine the selection of the proper oil to use in a steam cylinder operating under certain conditions. These recommendations have been general, as there are so many factors entering into the situation that a definite recommendation is difficult. Of course, the real test of a cylinder oil is the condition of the rubbing surfaces after it has been used. In making an examination of a cylinder running on a certain oil, too hasty a conclusion as to its value should not be reached. It takes time to form a film surface on a cylinder wall, and if possible several weeks should elapse before the action of the oil is finally judged. A perfectly lubricated cylinder should be highly polished and have a glaze over its surface. It should have no rough or dull spots, and there should be no sign of rust if examined immediately after stopping the engine. The color should vary from a bright iron-white to a light brown or steel blue. If the cylinder head is removed immediately after stopping the engine there should be a film of oil all over the surface sufficiently thick to saturate three or four thicknesses of cigarette papers. Even when the engine has stood for several hours there should still be a film upon the cylinder walls, though not necessarily as thick as if examined immediately after stopping the engine. The stain on the paper should be brown. If it is black or has black particles or streaks, the cylinder or rings are probably wearing or the oil is carbonizing. If there are pools of oil lying in the bottom of the cylinder or in the counterbore, too much oil is being fed and the quantity should be reduced. If the cylinder walls are dry in spots or show signs of wear, either too little oil is being fed or the wrong kind of oil is being used. Lack of lubrication will sometimes be shown when the engine is running, by sticky valves or groaning sounds from the cylinder. With Corliss valve systems, the slowness in action of the dash pot will give an indication as to the state of lubrication. Economy of lubrication can be checked up by examining the exhaust steam or piston rod leakage. If the condensed steam shows considerable quantities of liquid oil, either too much oil is being fed or it is not properly atomized. If it shows minute drops of oil and is milky in color it is probable that atomization is complete and the feed is correct. If the piston rod shows a film of oil on it and there is no oil fed directly to the piston rod it can be taken as an indication that the atomization is satisfactory, or at least that the surfaces are receiving sufficient oil.

Summary

In this article we have discussed the problem of steam cylinder lubrication, outlining the conditions that must be met and giving in a general way how they can be met and how the engineer can ascertain that he is getting good lubrication. The conditions which must be met are so variable and may appear in so many different combinations that it is practically impossible to make recommendations to cover each individual case. There are, however, a few general facts which stand out:

1. The lubricant must be of such quality that it will meet equally well the temperature conditions which may differ considerably in the various parts of the system.

2. The lubricant must be applied in an efficient manner. While the direct system is still used in some places the atomization system is generally preferable to the direct method as the steam, which acts as a carrier for the lubricant, reaches practically all points that it is necessary to lubricate.

3. In the atomization system the lubricant should be applied sufficiently far back in the main steam line as to secure complete atomization.

4. The ease of atomization depends upon the temperature, velocity and saturation of the steam, as well as on the design of the lubricator and the character and quality of the oil. High temperatures and high velocities give better atomization than low temperatures and velocities. Low viscosity oils atomize more quickly than high viscosity oils. Filtered oils atomize more quickly than unfiltered oils. Saturated steam is a better carrier than superheated steam. If it is necessary to introduce the oil close to the cylinder, one of low viscosity is generally necessary.

5. Steam refined and filtered oils are not necessarily better than fire stocks. Unfiltered and heavy bodied oils adhere to the cylinder walls better than filtered and light bodied oils. It is generally the practice to use the heaviest bodied oil that will atomize completely.

6. Mechanical lubricators as a general rule give better service than hydrostatic lubricators.

7. With high steam temperatures an oil of higher viscosity can be used than with low steam temperatures. High speed and vertical engines as a general rule require an oil of less viscosity than horizontal and low speed engines. Oils can be classified according to viscosity as follows:

Light bodied, 95–115″ Saybolt Universal Viscosity at 210° F.
Medium bodied, 115–135″ Saybolt Universal Viscosity at 210° F.
Heavy bodied, 135–160″ Saybolt Universal Viscosity at 210° F.

8. High temperatures cause greater evaporation losses than low temperatures.

9. High temperatures and excessive quantities of oil may cause carbonization. The more refined oils carbonize less than the fire stocks.

10. Compounded oils are more efficient than straight mineral oils, and should be used in all cases where wet steam conditions exist, unless it is necessary to recover the condensed steam. Even in the latter case compounded oils should be used if it is practical to separate the oil from the water. Compounded oils are separated from water with difficulty.

11. Priming boilers destroy the efficiency even of compounded oils. If this condition exists it is necessary to use an oil with high adhesive qualities, compounded to take care of conditions.

12. Boiler impurities separate from oils of low viscosity more satisfactorily than from oils of high viscosity. Compounded oils cause less trouble with boiler impurities than straight mineral oils.

The above points give a general idea of the type of lubricant to use. In studying any particular case it is generally found that there must be a compromise of qualities in order to get a lubricant that will be of the most practical value under the actual conditions. Unless an analogy can be made with some other engine of a similar type it is advisable when stipulating the character of a cylinder oil for a steam engine that the advice of a steam engineer experienced in lubrication should be requested. A careful inspection of the cylinder walls and other lubricated surfaces will reveal to this engineer whether or not the engine is receiving correct lubrication, and his experience will enable him to correct any defective lubrication if the same exists.

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2
-AND IN CONSEQUENCE HAVE HAD ALL KINDS OF ENGINE TROUBLE AND MOTORING HAS BECOME A NIGHTMARE
3
- AND YOU HAVE COVERED YOURSELF WITH OIL, RUINED CLOTHES AND DISPOSITION BY USING THE ORDINARY METHODS OF FILLING YOUR OIL CASE YOURSELF
4
AND THEN ONE DAY A FRIEND INTRODUCES TO YOU THE EASY POUR CAN CONTAINING TEXACO MOTOR OIL
5
-AND YOU GO TO THE NEAREST DEALER AND LAY IN A GOOD SUPPLY OF TWO QUART EASY POUR CANS CONTAINING THE PARTICULAR GRADE OF OIL FOR YOUR CAR
6
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